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From ISS to Human Space Exploration: TAS-I contribution and perspectives

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Abstract. The paper describes the contribution of Thales Alenia Space Italia (TAS-I) in Torino to the Human Space Exploration starting from the participation to the International Space Station (ISS) up to the new perspectives in the fields of the Space Habitats, Transportation Systems and related technologies. The contribution of more than 50% of the habitable volume of the ISS is underlined through the actual projects MPLM, Columbus, NODE 2 and 3, Cupola, ATV, ISS Payloads, and future initiative such as PMM, Cygnus/PCM, ISS Exploitation and other ATV missions. The perspectives are introduced in terms of re-entry demo missions and advanced transportation systems like EXPERT and IXV together with technology programs relevant to Inflatable Habitats, Crew Collaborative Robotics, Regenerative Life Support, Landers, Pressurized Rovers, Advanced Thermo-mechanical materials and propulsion. The TAS-I involvement in local initiative as the regional co-funded project STEPS and the International Master SEEDS are also emphasized.

1. Introduction

TAS-I in his Torino plant is considered a centre of excellence for Space Exploration both in robotic and human missions thanks to the long background in scientific, space infrastructures and transportation systems development. In particular as far as the human in space is concerning the activities started with the involvement in the Spacelab project (at that time the name of the company was Aeritalia) followed by the relevant participation as Alenia Spazio in the ISS activities. Today TAS-I activities in Human Space Exploration are really significant and the perspectives are encouraging as summarized in the following sections.

2. Contribution to ISS

The ISS is without doubts the largest space project never developed and sees the participation of tenth of nations and Space Agencies including NASA, RKA, ESA, JAXA, CSA and directly also ASI, the Italian Space Agency that has bi-lateral cooperations with NASA in addition to those existing through the European Agency.

The ISS has been defined as a new star in the sky for his dimension (larger than a football field) and the possibility to view it crossing the sky at a speed of 7 Km/sec and a height of about 400 Km during a clear night.Fig. 1 shows a recent ISS configuration taken from the Shuttle and almost at the end of its nominal assembly sequence supposed to terminate by middle 2011.

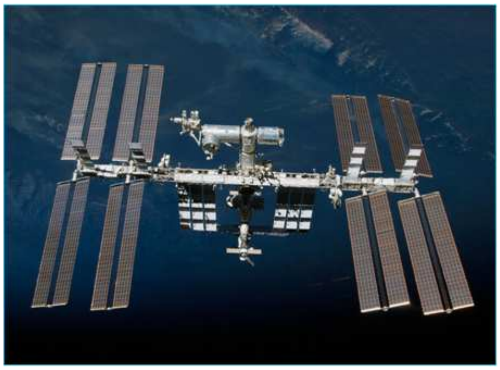

Fig. 1. Recent ISS configuration

TAS-I contributes to ISS with several modules that represent more than 50% of the habitable volume. Fig. 2 shows the modules already in orbit or in use. In particular MPLM is a fleet of three modules (named Leonardo, Raffaello and Donatello) built for ASI and used through shuttle flights for the NASA logistics of the ISS. MPLM made 10 flights so far and two additional are planned.

Node 2 (called Harmony), started also with the support of ASI and continued with the involvement of ESA, is a fundamental interconnecting element for other modules such as Columbus and the Japanese KIBO as well as the same MPLM and the Shuttle when attached to the ISS. Columbus is the ESA laboratory supposing to support experimentation in life and material sciences up to 2020 and TAS-I had in this project the co-prime responsibility towards Astrium for primary/secondary structure, ECLS, Thermal Control and harness.

The Node 3 (named Tranquillity) is flown to the ISS in March 2010 attached to the Cupola that is the most recent product built by TAS-I for ESA and represent an important "belvedere"for the astronauts ISS operations, experimentation and last but not least psychological well being.

The TAS-I contribution to ISS, in addition to the above habitable modules, sees also Columbus internal and external payloads facilities, namely Fluid Science Laboratory (FSL), European Drawer Rack (EDR) and SOLAR/Course Pointing Device (CPD) that are supporting different type of experiments.

The TAS-I future involvements in the ISS are summarized in Fig. 3, and consist in the continuation of the MPLM remaining missions including the so called PMM (Permanent Multipurpose Module) that is a modification of Leonardo wanted by ASI to became permanently attached to ISS after its last flight as additional habitats for future experiments and demonstrations, the continuation of ESA Automated Transfer Vehicle (ATV) flights after the first of Jules Verne (the next will be Joannes Kepler, beginning 2011, the subsequent Edoardo Amaldi in 2012, followed by other 2 as presently planned) in which TAS-I is building for Astrium the Pressurized Module (Integrated Cargo Carrier), and last but not least the development of 9 Pressurized Cargo Modules (PCM) to be part of the Orbital Cygnus cargo transportation system that won one of the NASA commercial resupply services contracts for the ISS.

In addition to these module development projects, also the ISS Exploitation contract with ESA will continue all along the ISS life (in these days under extension up to 2020 and more), including the operational support to ISS TAS-I modules through dedicated ASI and ESA contracts with the involvement of the ALTEC Mission Support Complex in Torino.

3. Perspectives in Human Space Exploration

Starting from the ISS experience TAS-I is contributing also to the projects oriented to prepare the Human Space Exploration towards Moon, asteroids, Mars including the capability to safely re-entry in the Earth atmosphere. In this context Fig. 4 is showing a series of technological projects devoted to a couple of fundamental technologies for the future Human Space Exploration: the inflatable structures and Regenerative Environmental Control.

In particular TAS-I has developed inflatable technologies under ASI FLECS project and the concept of an Inflatable Module under ESA IMOD study, both confirming the potentiality of this solution to increase the habi-

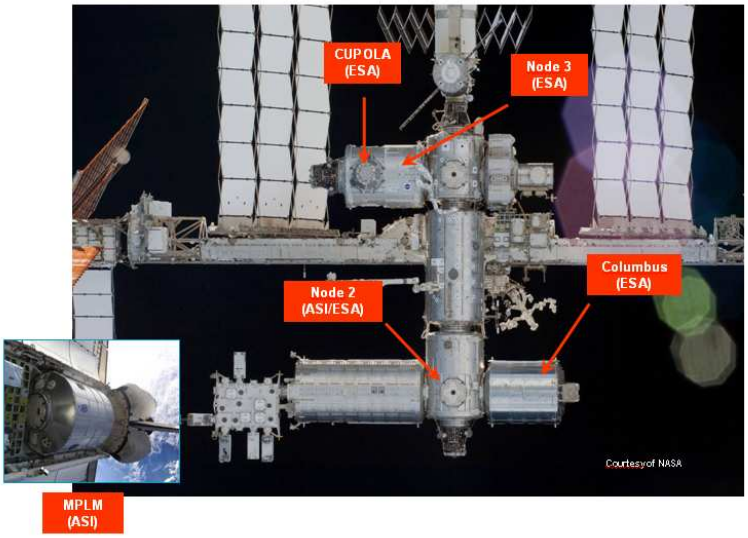

Fig. 2. TAS-I contribution to the ISS already in orbit/use

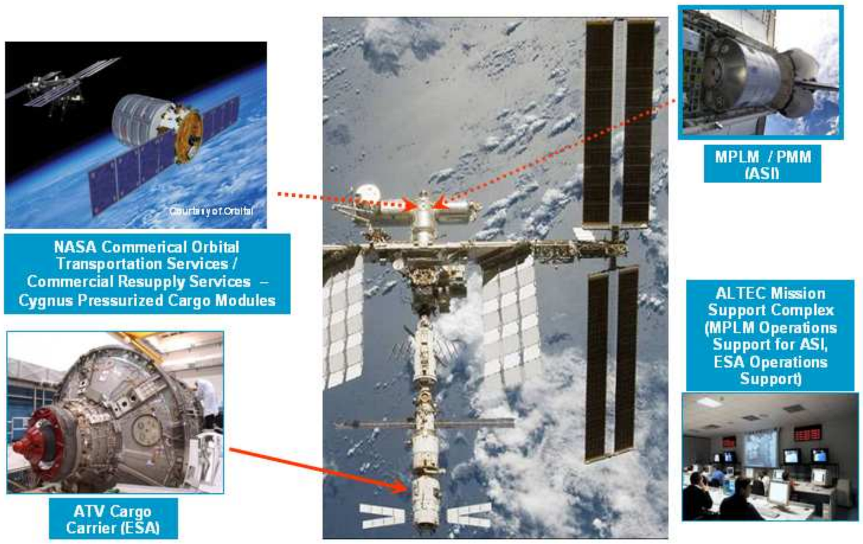

Fig. 3. ISS future development and operations involving TAS-I

tat operative volume without penalize launch volume and mass. Now TAS-I is in the process to propose in-orbit validation of the technology through a demo mission to ISS in the context of NASA and ESA usage of ISS as test bed for exploration. In the same direction are the two ESA studies in which TAS-I is engaged: FLEXWIN to develop a flexible solution for a module window and the ICM to demonstrate the suitability of an inflat-

Fig. 4. Preparation of Human Space Exploration new habitats technologies

Fig. 5. Preparation of Human Space Exploration Lander/rover/crew collaborative robotics/propulsion technologies

able solution for a Capture Mechanism to be used in the MARS SAMPLE RETURN mission aimed to validate the overall chain of a return from Mars that is fundamental for the future Human Exploration of the red planet. The Regenerative Life Support technologies are under development within the ASI series of studies called CAB (Controllo Ambientale Biorigenerativo) with the objective to demonstrate an high level of human resources recycling (food, water, air, etc.) that is fundamental for the future planets exploration be-

Fig. 6. Preparation of Human Space Exploration new transportation systems and technologies

cause would not be sustainable to bring resources from the Earth. Always in the same context Fig. 5 is showing other important enabling products and technologies for Human Space Exploration on which TAS-I is working. In particular TAS-I carried-out for ESA a study on a Pressurized Lunar Rover that is a potential European contribute for the Moon Exploration, a couple of ground prototyping projects called Eurobot to demonstrate concepts for Crew Collaborative Robotics within ISS and planet surface activities (in this respect an ISS demo mission is proposed in the next future), an hybrid propulsion development activity with CISAS aimed to demonstrate its suitability for a soft landing and a System Development study oriented to an innovative landing legs concept. In the same direction TAS-I collaborated with Boeing in the conceptual design phase of the NASA Altair Human Lander and is developing a series of space exploration enabling technologies for a Lander and a Pressurized Rover within the Piedmont Region co-financed project STEPS.

Again in the context of Human Space Exploration preparation activities, TAS-I is assuming an important role in the new generation transportation systems and associated re-entry demonstrators and technologies. In particular TAS-I is leading, thanks also to ASI strong support in this area, the only ESA initiatives existing in Europe since Hermes time, namely EXPERT the small ballistic test bed for re-entry technologies and IXV the ambitious Experimental lifting body demonstrator of re-entry technologies that includes advanced GNC capabilities and thermal protection solutions. Fig. 6 shows the two mentioned projects together other re-entry technologies developed by TAS-I for ESA i.e. Reusable Metallic Structures, Future Launcher Preparation Program (FLPP) Materials and Structures , Crew Space Transportation System (CSTS) ablative TPS, and for ASI i.e.

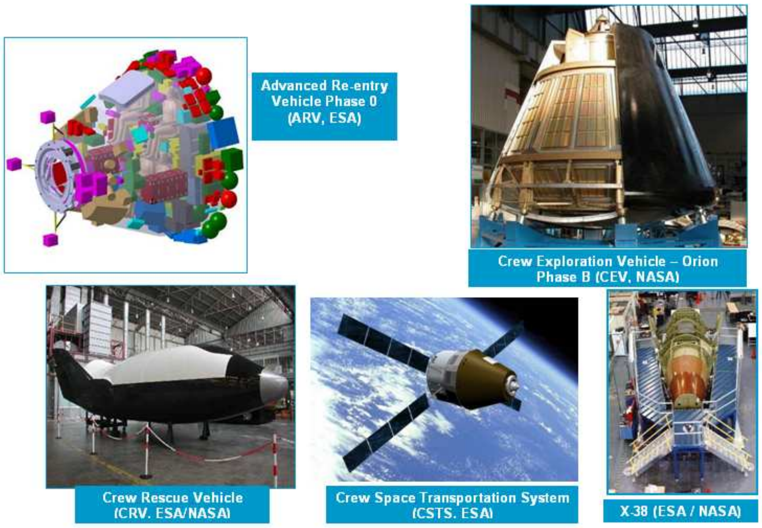

Fig. 7. Preparation of Human Space Exploration crew transportation initiatives

Advanced Structural Assembly (ASA) where new high performance solutions are investigated to sustain the heat and mechanical loads of a typical Earth return mission. Similar advanced studies and solutions are being investigated by TAS-I also for the crew transportation where both capsule and hi-lift concepts are included. Fig. 7 shows in fact several projects in this field that TAS-I developed for ESA and NASA, namely ARV phase 0, CEV Orion Phase B, CRV, CSTS and X-38 Studies. This is considered a valid background to support opportunities also in the Commercial Crew Transportation new scenario of NASA.

Fig. 8. Logo's of STEPS and SEED initiatives

4. Conclusion

TAS-I heavily contributes to the ISS and the perspectives of involvement in its evolution and operations are of primary relevance as well. From this background the perspectives in terms of new projects and enabling technology studies for Human Space Exploration see a deep involvement of TAS-I in subjects like space habitats (in particular for inflatable structures and regenerative life support), lander/pressurized rover/crew collaborative robotics/advanced propulsion, new generation transportation systems including crew transportation. In parallel the participation in these ASI, ESA, NASA and commercial programs, TAS-I is investing in internal research and in local initiatives within the Piedmont Aerospace District such as the Regional co-financed project STEPS and the Politecnico di Torino International Master SEEDS, this last devoted to prepare System Engineering post-graduated resources specialized in Human Space Exploration (see the relevant logos in Fig. 8). In conclusion TAS-I is paving the way to confirm its role of excellence in the world wide strategies and plans for Space Exploration.